Space Weather Technical Forecast

Issued on Monday, 04 April 2022 at 01:17 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

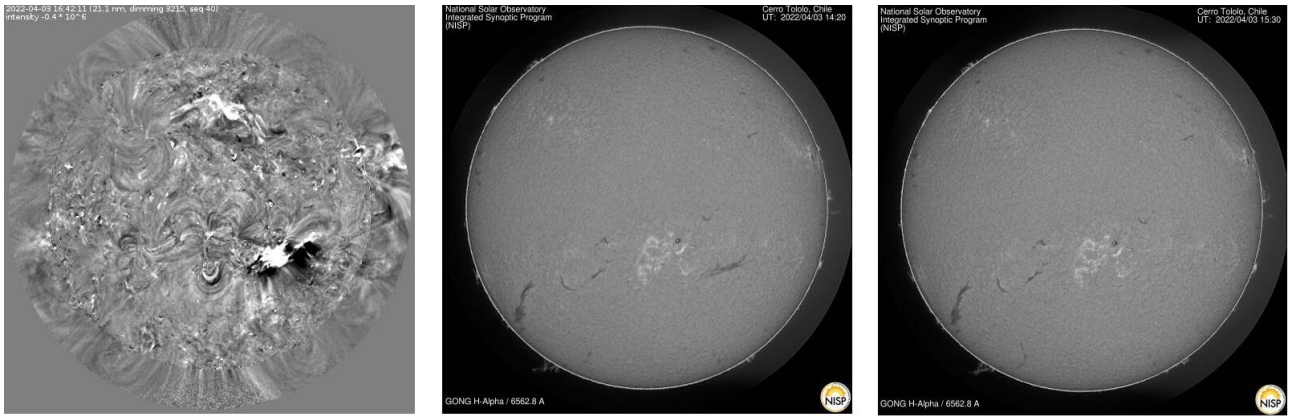
Space Weather Forecast Headline: Decreasing risk of Minor/Moderate radio blackouts. Possible Minor/Moderate Geomagnetic Storm from CME due midweek, detail TBC.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with the largest flare of the period observed at GOES16 a C6.4 at 03/1309UTC. This emanated from the vicinity of AR2976 in the northwest quadrant near the western limb. There are currently seven sunspot regions remaining on the visible disc, with the most active group of the past week, AR2975, now no longer visible on the northwest limb. Detail in its immediate trailing groups of AR2984 and 2976 is also likely to be hampered by the narrowing viewing angle, however both now appear unipolar at Hrx and Hhx respectively. There were a further three minor unipolar groups visible in the eastern solar hemisphere, with all of these stable and unremarkable. This left the near centre-disc pairing of AR2978, a Fhi/Beta, and AR2981, a Cri/Beta as the main regions on the facing side, although both showed a spreading trend with their intermediate spots fading.

There remain numerous large filaments on the disc. The most notable event of the 24 hours was the lifting off of the large south-centre filament mentioned in weekend guidance updates - at 03/1500UTC. This event was visible in coronagraph imagery and a cursory analysis has been conducted - an Earth-bound component is very likely, most probably passing Earth midweek UTC, with further detail and discussion to be found in the geomagnetic activity section. No other Coronal Mass Ejections (CMEs) were visible in available imagery.

Figure 0: Left: time-integrated AIA 211 imagery (courtesy of SIDC ROB) of dimming from 03/1500UTC filament eruption. Also shown are Cerro Tololo H-alpha images straddling the relevant time period, with the filament in question in the southwest quadrant.



Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, showed a gradual decline in many solar wind measures in the period, perhaps indicating an exit from negative polarity high speed stream influence and perhaps also residual CME effects. The solar

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wind speed fell from near 525km/s to reach 450km/s before undergoing a step-wise increase to fully regain lost ground at 03/1500UTC. The cause of this resurgence is uncertain, however the effect on geomagnetic activity was slight. ACE EPAM LEMS low energy protons are currently showing a rise across the spectrum. Whilst the cause of this is uncertain, it may be a close pass from the 31 March M9.6 CME from AR2975, as this is indicated in MOSWOC Enlil as passing 1AU at this time, narrowly ahead of Earth in the track of its orbit.

After the discontinuity in speed at 03/1500UTC, it again decreased to end the 24 hours near 475km/s. The solar wind density was within its typical background range in single figures ppcc throughout, while the IMF showed a roughly level trend, with a peak of 8nT and a north-south range of +5/-8nT. The phi angle was negative (towards the sun) throughout, albeit with a step change evident to approach neutral after 03/1500UTC.

The net result of the above solar wind measures was mainly Quiet, with a provisional peak Kp of 3+ in the 00-03UTC interval.

Energetic Particles / Solar Radiation: The high energy proton flux (10MeV) measured at GOES-16 showed a continuing gradual relaxation towards Background levels, having reached S1/Minor Storm prior to the 24-hour reporting period (at 02/1430UTC). This was in the wake of an M-flare from the northwestern limb.

The high energy (greater than 2MeV) electron flux as observed by GOES-16 at GEO showed an increased amplitude diurnal oscillation between Moderate and High flux, peaking at 2600pfu at 03/1505UTC. The 24-hour integrated fluence showed a steep rising trend followed by a gradual plateau, with 9.4e7 integrated pfu recorded at 04/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: The chances of further significant flares should soon reduce into the new working week, as the northwestern quadrant spots leave the Earth-facing disc. Activity should be predominantly Low, with a much-reduced daily Chance of M-class flares.

Solar Wind / Geomagnetic Activity: An exit from the current fast wind is expected into the new working week, with no further coronal holes forecast and mainly Quiet activity. The 03/1500UTC south centre disc filament eruption constitutes the only possible CME in the forecast, giving a peak risk of Minor/Moderate geomagnetic storm G1/G2 midweek UTC. This is a cursory analysis based on limited imagery and will be refined in future guidance updates.

Energetic Particles / Solar Radiation: The risk of further solar radiation storms should now slowly reduce as the northwestern sunspot regions rotate off the disc.

The high energy (greater than 2 MeV) electron flux may show a slight day-on-day increase in the immediate term, in the wake of recent fast wind influence and now that residual CME activity has passed. Active fluence is Likely as a result, although this aspect is marginal. Flux levels may then be attenuated by the 03/1500UTC CME's arrival, currently mooted for Wednesday 06 April, with any recovery in fluence following this probably insufficient to breach Active.

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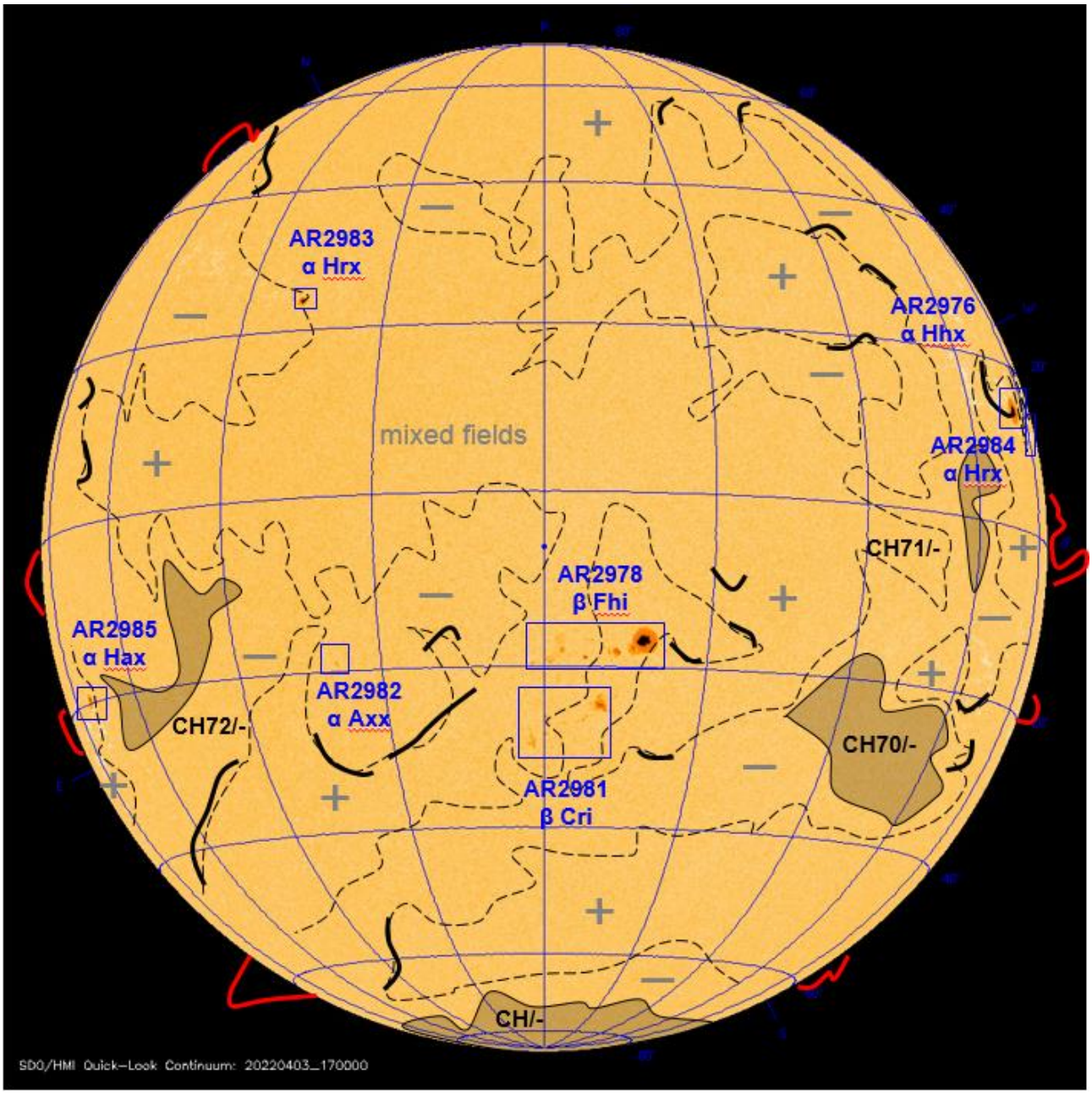
Figure 1. Solar Analysis Valid 03/1700UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Earth now appears to be undergoing a gradual exit from high speed stream influence, most likely that from CH70 or CH71 near the western limb. The solar wind speed is tracking close to levels seen on last rotation, and in this respect it should continue a gradual decline into the coming working week UTC, with no further fast wind enhancements expected, and mainly Quiet geomagnetic activity resulting.

There is one potential CME in the forecast, that emitted from a southwestern quadrant filament eruption around 03/1500UTC. This can be seen heading mainly ahead of the Earth in its orbit, however imagery arriving subsequent to the cursory analysis suggests that there is more of a halo signature in coronagraphs than first suspected, and a more direct hit is not out of the question. Current early MOSWOC Enlil modelling suggests a blow from the eastern side of the CME is Likely within the UTC day of Wednesday 06 April, perhaps 06/0700UTC with even the centre line of the ejecta reaching 1AU on the same day, albeit earlier at 06/0001UTC. This gives reasonable confidence in the arrival of the CME within this 24-hour, although further analyses will be conducted overnight UTC to give a better estimate. Although the associated flare was not huge (being low C-class), the fact that this is a filament and therefore of potentially greater 'heft' than a sunspot-generated CME means that G2 cannot be ruled out, although higher G-scale effects are perhaps unlikely.

There is a Slight Chance of residual effects from the now waning fast wind in the immediate term, perhaps occasional Unsettled intervals. However, provisionally, the then largely Quiet geomagnetic forecast is dominated by the prospect of G1 Minor Storm from the filament CME, with this most likely arriving within the UTC day of Wednesday 06 April. This early estimate will be refined in future guidance updates.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	5	75	10
Strong	G3	No	1	1	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
03/04/2022 21:13	Full	Filament eruption	Centre-SW quadrant	851	06/0700UTC	Early analysis, although arrival probably within same UTC day.

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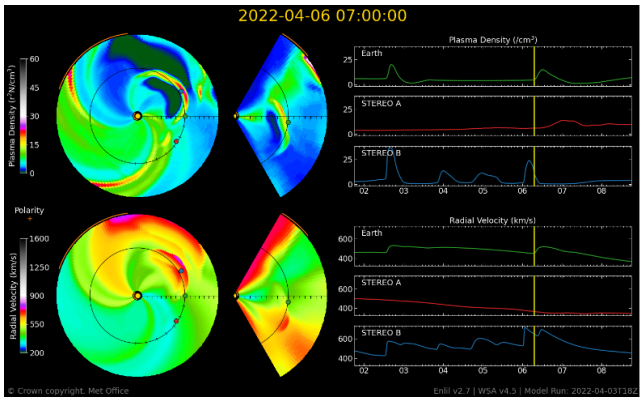
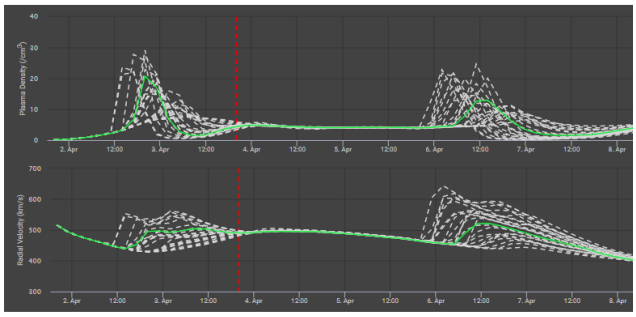
Figure 2: Cursory MOSWOC Enlil run showing the 03/1500UTC filament eruption as provisonally reaching Earth around 06/0700UTC. The bulk of the ejecta crosses 1AU a few hours earlier, but still within the same UTC day (passing the vicinity of STEREO B's current location around 06/0001UTC). This initial assessment will be refined as more imagery becomes available.





Radio Blackouts - X-Ray Flares:

The sun now appears to show an overall waning in X-ray activity, particularly given the departure from the Earth-facing side of AR2975, the past week's most active spot by far. This should shortly be followed by AR2984 and 2976 in quick succession, leaving unipolar groups and the fading AR2978 and 2981 near centre disc.

There are numerous bright flux regions hinted at in STEREO A EUVI 195 imagery between 120 and 90E. These may offset the departing regions to some degree, however these will be analysed in due course and do not yet feature in the forecast.

Overall, the chances of significant X-ray flares should reduce in the coming four days, with the majority of this decrease occurring at the very start of the period. M-class flares are rated at a daily Chance throughout, largely the result of the raw potential of AR2978 and perhaps also AR2981, although this has not been borne out in their activity, and their growth phase appears to have stalled for the time being.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	No	40	25	25	25
Very Active	**R3 to R5 X Class**	No	10	5	5	5

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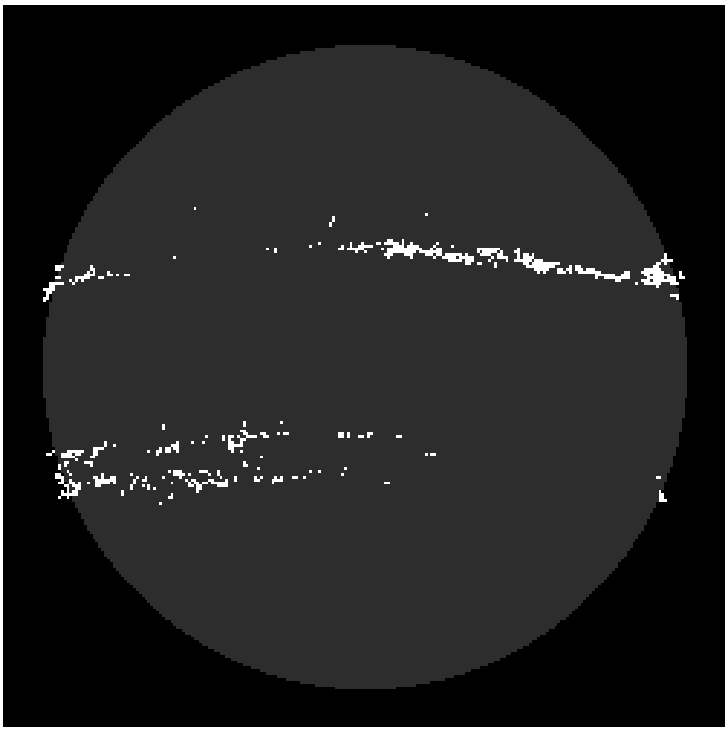
Figure 3: Point locations of all flares in the last two weeks – the dominant stripe in the northern solar hemisphere is the trail wrought by AR2975, with frequent C-class, as well as a handful of M and even an X class flare. This group has now crossed to the far side. Other honorable mentions go to AR2978 and AR2981 in the southern solar hemisphere, although these flares were confined to C-class, and they have become fewer in recent days (fading with westward advance) as the groups' growth has stalled. Image courtesy of SIDC ROB.



Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) is now well below the S1/Minor Storm threshold but remains above normal background levels. This is expected to continue to decline back to normal background levels later in the period.

The source of all the recent S1 and near-S1 level enhancements is now on the northwestern limb, and from here its contribution to the risk of further such events should begin to lessen, with this hastened by AR2976 and 2984 soon following suit. The residual risk of S1 should then be inherited by the westward advance of the large but relatively quiescent AR2978 and 2981, perhaps offering a lower ongoing risk through midweek.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	No	15	10	10	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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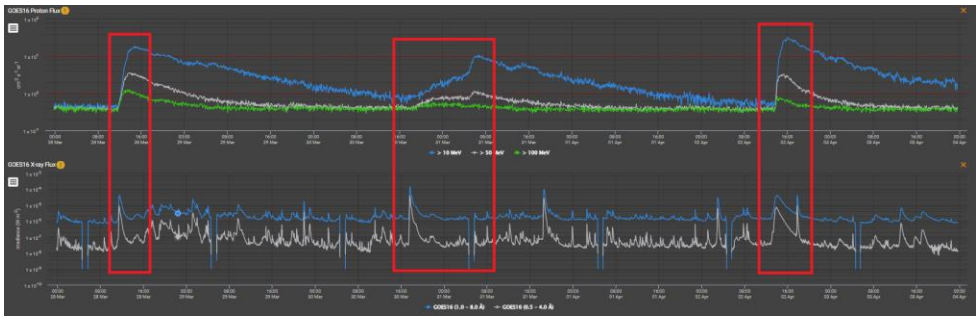
Figure 4: Past week in GOES 16 high energy protons (top) with GOES 16 X-ray flux shown below. All of these S1-level solar radiation storms were generated by AR2975, and similar remains possible in the near term while the group remains only narrowly over the western limb.

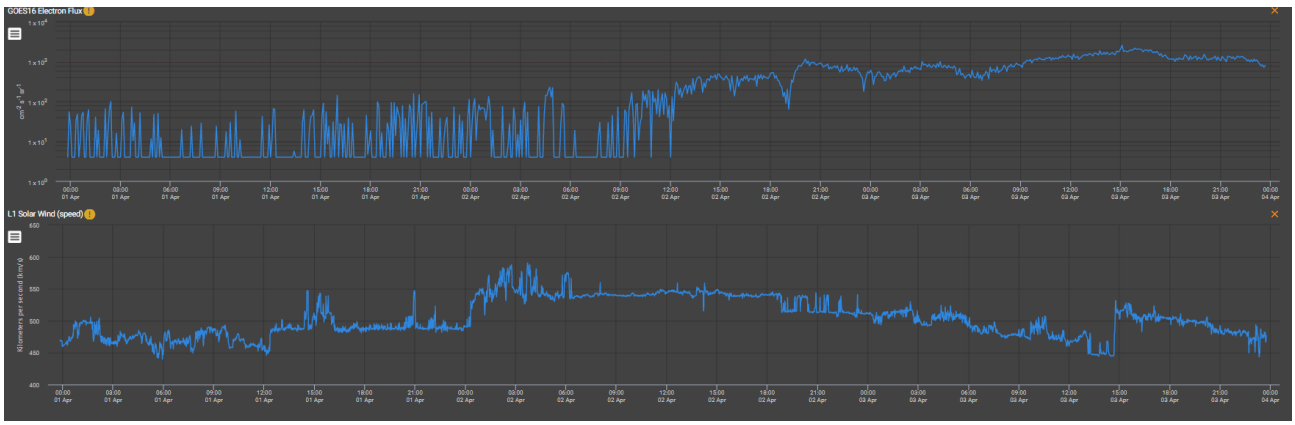


High Energy Electrons Event (≥ 2MeV):

A slight day-on-day increase in high energy electron flux is possible into the start of the coming working week, however the chances of breaching 24-hour integrated Active fluence are near evens, perhaps slightly more likely than not. The forecast confidence then drops significantly given the possible presence of a CME in the forecast, with this most likely to attenuate counts from midweek UTC, with any recovery following this probably insufficient to result in any further Active levels. The CME estimate is currently based on incomplete information and may be updated in future guidance, although the general trend of a a step-wise decrease in flux and fluence around the middle of the coming week still holds.

GEO Electron Environment	**Level (cm^{-2} sr^{-1} day^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ 2 MeV ≥ $1x10^8$**	No	60	60	50	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: Past three days in GOES 16 high energy electron flux (greater than 2MeV, top) and L1 solar wind speed (bottom). The current diurnal oscillation may increase a little in the near term, before any attenuating and redistributing influence from the 03 April filament eruption CME, due around midweek UTC.



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